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R&D: Cornerstone of the Knowledge Economy

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R&D:

Cornerstone of the Knowledge Economy

by Evan Richert

Thirteen years ago the State Planning Office projected that the state's low per capita income would reach the national average if 30 percent of the state's adults had at least four-year degrees and if businesses, academia, and government were spending $1,000 per employed worker on research and development. Evan Richert, in a detailed analysis of Maine's R&D expenditures, argues that although Maine has made progress in achieving that goal, business needs to nearly double its effort to reach its share of the total. This will require continued retooling of traditional industry and emergence of new, high-performing R&D businesses. Richert recommends an annual commitment by state government of 5 to 7 percent of the total requirement, which would help businesses, universities, and research institutions leverage the rest.

If…

- at least 30 percent of Maine's adults had at least four-year college degrees
- industry, universities, and research institutes in the state spent about $1,600 per employed worker in the state (or about $1 billion) annually on research and development
- industry accounted for about 70 percent of the R&D expenditures
- it is probable that per capita income in Maine would equal or exceed the nation's.

This article reports on the relationship among higher education, R&D investments, and income and reviews progress made in Maine in each of these areas over the last 15 years.

30 AND 1000

In 2001 the Maine State Planning Office (SPO) published the report *30 and 1000*. The 30 referred to a goal of 30 percent of adults with at least four-year college degrees, and the *1000* referred to a goal of $1,000 per year of research and development per employed person in the state. The publication was a culmination of a three-year ramp-up in the state's contribution to R&D that included

- a $20 million R&D bond approved by voters in November 1998, the first of its kind in Maine
- establishment in 1999 of the University of Maine System's Economic Improvement Fund as an ongoing program for university-sponsored R&D
- establishment in 1999 of the Maine Technology Institute [MTI] as an ongoing program with a focus on industry and commercialization of R&D
- establishment in 2000 of the Maine Patent Program
- initial state funding for biomedical research laboratories in 2000
- initial funding of the Small Enterprise Growth Fund (now the Maine Venture Fund)
- an expanded Seed Capital Tax Credit Program to invigorate angel investing in early-stage businesses

The initial impetus that eventually led to publication of *30 and 1000* was not R&D itself. Rather, it was a question posed by then Governor Angus S. King Jr.: Why are Maine's incomes chronically lower than the national average? The subtitle of the report was, "How to Build a Knowledge-Based Economy and Raise Incomes to the National Average by 2010." At the time, Maine's per capita income was persistently 85 percent to 88 percent of the national average, which represented a penalty on the state's economy of $3 billion (Maine SPO 2001).

Gov. King's question was a big one with many-sided answers. A rural location distant from large metropolitan areas is likely part of the reason why Maine's incomes are lower than the national average, but at the time there were states with rural population densities distant from large metropolitan centers that had higher incomes (e.g., Vermont, Kansas, Oregon). There were also too many exceptions among the states to the commonly cited maladies—high energy costs, relatively high tax burden, and the regulatory environment, for example; these factors may have been partly to blame, but did not seem to be the driving forces.

Meanwhile, the work of several economists and business thinkers—Peter Drucker, Michael Porter, Richard Florida, and W. Edwards Deming, among others—pointed to the rising *knowledge economy* and the imperative of innovation as central to the success of regional and state economies.[1] The knowledge economy, as successor to the industrial and post-industrial service economies, increasingly relied on knowledge workers for its labor input. These workers cover a wide spectrum of occupations, including science, technology, engineering, publishing, digital and other media, design professions, and the arts. Their common denominator is the discovery, generation, use, management, or distribution of knowledge and information, often involving intellectual property. The development of this workforce requires quality education at every level, kindergarten through postsecondary. And research and development—both basic and applied—underlie the innovation that fuels either their work or the processes and technologies that expedite their work. Research and development is a surrogate for the innovation that enables economic growth.

This led to an investigation of the relationship of educational attainment and of investments in R&D to per capita income. Among the 50 states and District of Columbia, SPO found a strong, statistically significant correlation between the percentage of adults with at least four-year degrees and the states' per capita incomes. It also found a statistically significant correlation between educational attainment and the amount per employed worker expended in the states on R&D (by all parties—businesses, academia, and research institutes). Finally, the combination of educational attainment and R&D per employed person explained a majority of the differences in per capita incomes between the states. The resulting regression formula predicted that if Maine, as of 2000–2001, had achieved a 30 percent share of adults with four-year degrees and roughly $1,000 of R&D per employed person, its per capita income would have equaled or exceeded the national average.

THE RELATIONSHIPS REVISITED

These relationships hold true today. A review of state data on personal income, educational attainment, and R&D expenditures per employed person in the civilian labor force found the statistically significant correlations shown in Table 1.[2]

A regression using percentage of adults with at least a bachelor's degree and R&D spending per employed person as the independent variables and per capita personal income as the dependent variable predicts that if (as of 2010) at least 30 percent of Maine's adults had at least a bachelor's degrees, and businesses, academia, and research institutes in the state spent $1,567 per employed person annually on research and development, the state's per capita personal income would have equaled the 2010 national per capita income of $40,129. (The summary outputs of the regression are available from the author on request.)

Table 1: Correlations of Per Capita Income, Percentage of Adults with Bachelor's or Higher Degrees, and R&D Spending Per Employed Person, States and District of Columbia

Variables	Correlation (r^2)
Per capita income and percentage of adults with BA+ degrees	0.74
Per capita income and R&D spending per employed person*	0.43
Percentage of adults with BA+ degrees and R&D spending/employed person	0.56

*Excluding three outliers: DC (very high R&D and per capita income, mostly federal government); New Mexico (high R&D and low per capita income—R&D concentrated in a single federal lab); and Wyoming (low R&D and rapidly rising per capita income attributable to recent domestic oil and gas boom)

The 30 percent of adults with at least bachelor's degrees is the same target as projected in the 2001 *30 and 1000* report. The $1,567 per employed person represents more than a 50 percent increase in the target in current dollars and about a 27 percent increase in real dollars—a sign not just of inflation since the original 30 and 1000 but also of the increases in R&D elsewhere in the United States. This level of R&D spending per employed person multiplied by an employed labor force in Maine (in 2010) of 633,000 would yield total R&D spending of about $1 billion.

WHERE MAINE STANDS

As of 1998, when Maine began its ramp-up of R&D investments, the state's performance in both percentage of adults with at least four-year degrees and R&D spending per employed person fell well short of the targets of *30 and 1000*: only an estimated 19 percent of adults had at least a four-year degree, and $255 per employed person was spent for R&D (by all types of entities).

From 1998 to 2010, the improvements in both categories were substantial: the percentage of adults with at least a four-year degree reached 27.3 percent and R&D spending per employed person as of 2008–2010 (in current dollars) was $1,016. In real dollars, the increase was from $255 to $759 per employed worker, an increase of 198 percent. The R&D investment for 2008-2010 also represented an average of about 1.3 percent of Maine's gross domestic product, up from about 0.5 percent in 1998 (Table 2).

Per capita personal income, meanwhile, has moved up to about 92 percent of the national level. It is not possible to ascribe the growth in income to these factors alone or to assert that they were the primary influences, but their correlations with income suggest they are at least important contributing factors.

Thus, Maine is a little less than three percentage points from the target of 30 percent of adults with four-year or higher degrees. It is still about 45 percent below the revised target of about $1,600 of total R&D expenditures per employed worker, which would translate to just over 2 percent of today's gross state product.[3]

TABLE 2: **Educational Attainment, R&D Spending, and Per Capita Personal Income, Maine and United States, 1998 and 2010**

	Maine	U.S. Average
1998		
Percentage of adults with 4+ yr degrees	19.2%	24.4%
R&D spending/emp person	$255	$1,106
R&D spending as percentage of gross state product	0.5%	2.3%
Per capita personal income	$23,500	$27,300
Maine as percentage of U.S.	86.1%	---
2010		
Percentage of adults with 4+ yr degrees (ave. 2008–2012)	27.3%	28.5%
R&D spending/employed person (current $$, ave. 2008–2010)	$1,016	$2,783
R&D spending as percentage of gross state product*	1.3%	2.8%
Per capita personal income	$36,881	$40,129
Maine as percentage of U.S.	91.9%	---

*This level of R&D spending is somewhat higher than reported by the National Science Foundation, because the NSF data are incomplete for nonprofit institutions outside of universities and colleges. These institutions are disproportionately important to R&D spending in Maine. Adjustments were made to Maine and United States based on reviews of annual reports of the major research institutions in the state and based on NSF's estimate of under reporting for these institutions nationwide (NSFA 2010, 2012, 2013: Table 10, footnote f).

THE BIGGEST SHORTFALL: INDUSTRY

Research and development performers include businesses, universities and colleges, research institutions outside of universities and colleges, and government. These performers receive money for R&D from both private and public sources. Nationally, the share of R&D expenditures by type of performer is heavily weighted to businesses: overall, more than 70 percent of R&D spending is by businesses. In a few states, including the District of Columbia, that are strong both in R&D investments and in per capita incomes, businesses play a smaller role. But these jurisdictions are heavily influenced by the presence of federal government agencies and laboratories. In most states with both strong R&D investments and high per capita incomes, business R&D spending ranges from 65 percent to more than 90 percent of the total. Of the 10 states (including DC) with at least the national average of $2,700 of total R&D spending per employed person and per capita incomes above the national average, seven are outside of the DC Beltway; business in these states accounts for 68 percent to 91 percent of total R&D spending (Table 3).

In Maine, businesses account for only 56 percent of total R&D spending, which ranks among the bottom third of states in the share of business spending on R&D. This modest share likely reduces the impact of R&D on incomes. Intuitively, business R&D spending translates most quickly into commercialization, jobs, and income. And statistically, there is a positive, significant correlation between business R&D spending alone and per capita personal incomes (r^2 = .33; detail available from the author on request).

Business R&D spending per employed person in Maine averaged $573 per year from 2008 to 2010. To get to 70 percent, which would be close to the national average, of the revised target of $1,600 in total R&D spending per employed person, Maine businesses would need to nearly double their R&D spending. Academia, other nonprofits, and federal agencies are much closer to what might be considered reasonable shares of the target (Table 4).

TABLE 3: **Percentage of R&D Performed by Business, by Jurisdictions with R&D Expenditures/Employed Person >$2,700 and Per Capita Personal Income >U.S. Average**

Jurisdiction	Total R&D/ Employed Person (2008–2010 Average)	Performed by Business %	Per Capita Personal Income (2010)	Note
United States	**$2,783**	**73**	**$40,129**	
Maine	**$1,016**	**56**	**$36,881**	
District of Columbia	$15,483	10	$69,304	Federal government dominated
Massachusetts	$6,687	68	$51,102	
Maryland	$6,406	24	$49,691	Strong federal government presence
Connecticut	$5,866	91	$55,048	
Washington	$5,615	82	$42,923	
Delaware	$5,266	91	$41,133	
California	$5,101	81	$42,487	
Virginia	$2,917	51	$44,605	Strong federal government presence
New Hampshire	$2,788	83	$44,373	
Minnesota	$2,762	84	$42,294	

THE CHALLENGE TO INDUSTRY

It is not surprising that Maine's businesses lag far behind in R&D expenditures. The industrial sectors in which Maine has traditionally been strong relative to the nation tend to be sectors that do not invest heavily in R&D. Conversely, Maine is weak in the sectors that do invest heavily in R&D.

According to the National Science Foundation, business sectors that invest in R&D spend on average 2.6 percent of their sales revenues on R&D. The most intense R&D industries spend considerably higher shares, e.g., the chemicals industry spends 5.9 percent of sales, led by its pharmaceuticals and medicines subsector, which spends 13.4 percent. The computer and electronic products industry spends 6.5 percent of sales, led by its semiconductor subsector, which spends 12.2 percent, and its communications equipment subsector, which spends 10.1 percent. The publishing industry, led by software publishing, spends 8 percent. The top 15 to 20 industrial sectors or their significant subsectors spend at least 3 percent of sales on R&D.

Maine—as measured by location quotients (a measure of specialization in an industrial sector vs the United States)—does not have a significant presence in any of these high R&D-spending sectors. Maine does have competitive strength in several industrial sectors that spend on R&D, but all of these spend less than the 2.6 percent average for all R&D-spending businesses, and for the most part considerably less. For example, the paper-manufacturing industry reinvests in R&D at about half the average rate (1.3 percent of sales).

Figure 1 summarizes the situation. The bars represent the percentage of the business sector's sales spent on

TABLE 4: **Maine Existing and Target R&D Expenditures by Performing Sector**

		Performing Sector (with funds from all sources)*		
	Total R&D Spending	Business	Universities, Colleges, Other Nonprofit Organizations	Federal Agencies
2008-10 Average				
Annual Total ($000)	$643,000**	$363,000	$264,000**	$16,000
Per employed person	$1,016	$573	$417	$25
Suggested Target				
Annual Total ($000)	$1,012,000	$708,960	$283,584	$20,256
Per employed person	$1,600	$1,120	$448	$32
Needed Increase (2010 $$)				
Annual Total ($000)	$369,800	$345,960	$19,584	$4,256
Per employed person	$584	$547	$31	$7

*Performing sector is different from funding source. Funding sources include private investments and contributions, federal government, and state government. In 2010, for example, federal funds accounted for 48 percent of university and college R&D spending and 6 percent of business R&D spending (source: NSF 2013).

**Includes adjustment to NSF data made to account for under-reporting of nonprofit R&D expenditures.

R&D, and the sectors (and their significant subsectors) are listed in descending order. The figure includes only sectors that spend at least 0.5 percent of sales on R&D, as reported by the National Science Foundation. The connected dots represent location quotients: an LQ of 1.0 indicates average specialization in a sector based on percentage of nonfarm wage employment in that sector compared with the United States as a whole. Greater than 1.0 implies greater than average specialization, which in turn implies competitive advantage in that sector. Most of the half dozen R&D-spending sectors shown in this table for which Maine demonstrates LQs greater than 1.0 are concentrated in the right half of the chart, where sector R&D spending is below average. The exception is the transportation-manufacturing sector that includes aerospace; Maine's relatively strong LQ in this subsector is due primarily to the presence of Pratt & Whitney. On the left half of the chart, where the sectors most heavily invested in R&D are included, Maine's LQs tend to be well below 1.0, often virtually zero. Maine's LQ for one strong R&D-spending sector, "other information," which includes web portals, is at about the national average.

It should be noted that a low LQ does not mean that there is not any important employer in that sector in Maine. For example, IDEXX Laboratories, which develops and manufactures diagnostic tools for veterinary, food, and water-testing markets, is a major employer in the category of professional, scientific and technical services. But Maine's LQ for this sector is 0.68, indicating that a large cluster has not yet grown up around this activity. Similarly, Fairchild Semiconductor has had a long presence in Maine, but without any particular advantage to compete with Silicon Valley or similar locations, a strong cluster never grew up around it, and Maine's LQ in semiconductors and other electronic components—one of the business sectors most heavily invested in R&D and innovation—is vanishingly small at 0.09.

At the same time, R&D spending data are not available for certain niches—represented at the five- or six-digit level of the North American Industrial Classification System (NAICS)—that may in fact be high R&D performers and in which Maine in fact has above average location quotients. These niches often are small components of a larger business sector, and to the extent that they may be higher R&D performers, they are masked by the data available at only the more general level.

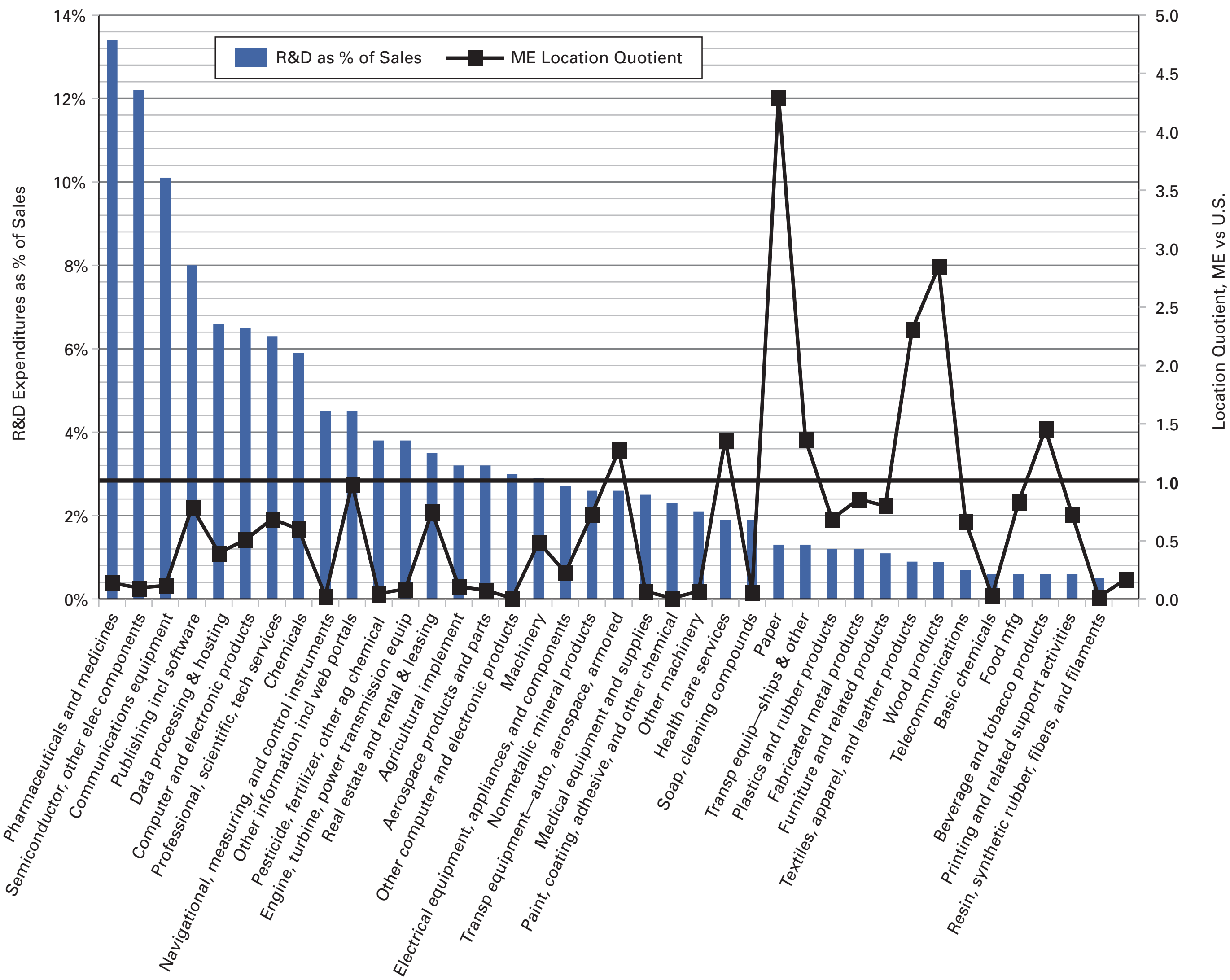
For example, the general sector of finance and insurance is not a high R&D performer, investing just 0.2 percent of sales in R&D. But a small subsector within finance and insurance, financial transaction processing, may be. WEX (Wright Express), which has pioneered fleet cards and developed proprietary software to do so, is based in Maine and helps the state achieve a location quotient of 1.89 in this subsector (NAICS 522320). Similarly, architectural and engineering services as a whole invest just 1.0 percent of sales revenues in R&D, and for this general sector Maine's LQ is below average. But a subsector, surveying and mapping, includes innovative technologies such as geographic information systems that invite R&D and product development. Maine businesses employ fewer than 500 in this subsector, but they include companies such as DeLorme, J.W. Sewall, and KAPPA Mapping. Further, the University of Maine has a strong spatial information science program and a related research institute. This subsector (NAICS 541360 and 541370) in Maine, as small as it is at present, has an above average LQ vs. the U.S. LQ, at 1.24.[4]

RISING TO THE CHALLENGE

Broadly speaking, there are two paths that Maine can follow to greater industry investment in R&D and innovation that, in turn, can lead to job and income growth:

One path retools sectors in which Maine has been traditionally strong, as represented by high LQs, but that are typically low R&D performers. This retooling uses applied R&D to develop new products and processes for export to the rest of the world. Outstanding examples are available in several of the state's legacy sectors. For example, the wood products sector overall is a very low R&D performer (less than 1 percent of sales reinvested in R&D), but Maine is a leader in new dimensions of the sector. These include engineered wood composites and forest bioproducts, both of which are investing heavily in R&D and trying

FIGURE 1: **R&D Expenditures as Percentage of Sales by Industry Sector* and LQ, Maine vs. United States (*for sectors investing at least 0.5 percent of sales in R&D, 2010)**



to commercialize the results. Composites, including those developed at the University of Maine's Advanced Structures and Composites Center, are being used by Maine businesses to produce decking, marine infrastructure, and bridges. As a business leader in forest bioproducts, Old Town Fuel and Fiber is developing the means to process wood into cellulosic sugars to make plastics and ethanol, using technology developed at the University of Maine. In fact, the university has located its Forest BioProducts Research Institute on the grounds of Old Town Fuel and Fiber mill.

Elsewhere in the paper-manufacturing sector, Sappi Fine Papers in Westbrook has successfully transformed itself into a world leader in the production of release paper, a specialty paper that creates the texture on products ranging from sporting equipment to clothing. The special coating is applied and cured with electron beams, and the wide use of release papers is in constant development by Sappi's in-house R&D division, also located in Westbrook.

The other path involves sectors that are high R&D performers and in which Maine's LQs are low—but also in which new technologies and applications provide new openings for Maine businesses to penetrate the sectors. Maine, through educational programs, academic R&D infrastructure, and entrepreneurs with intellectual property in these areas, has gained traction in several such sectors. For example, in the high R&D-performing pharmaceuticals sector, Cyteir Therapeutics, a spinoff company from the Jackson Laboratory, will become a presence in the pharmaceuticals industry if it succeeds in its mission to develop low-side-effect medicines to treat cancer and other diseases of the immune system.

Several companies are developing and commercializing chemical, biological, and particle-detection and analytical instruments. Measurement and control instruments are one of the top-ten R&D-performing sectors nationally. Among the companies are spinoffs from the University of Maine's Laboratory for Surface Science & Technology (LASST), such as Orono Spectral Solutions (OSS), which has developed materials and methods that enable trace-level detection of chemical and biological agents; and Environetix, which has developed a wireless sensor system for measuring heat and vibration in extreme environments such as jet engines. Another UMaine spinoff, Sensor Research and Development, specializes in instruments to deliver and detect gases; and Fluid Imaging Technologies, a spinoff from the Bigelow Laboratory for Ocean Sciences in East Boothbay produces particle analysis instrumentation using digital imaging technology.

The process filtration industry is tiny in Maine. However, a startup company, Orono-based Cerahelix, has developed a nanofiltration membrane using DNA and ceramics that filters solutions, including water for reuse and recycling, to high purity under harsh conditions. This could lead to an important presence in the kind of specialized manufacturing sector that tends to invest in R&D.

The Maine Technology Institute is heavily engaged in promoting both paths to higher R&D performance and commercialization. One strategy is its "cluster initiative program," which has supported both the retooling of traditional industries and the emergence of new industries through R&D and commercializing the results. According to MTI's website (www.mainetechnology.org), clusters are "concentrations of companies that serve similar customers and draw on similar knowledge and workforce skills in the development of innovative products and services. They are actively supported by common organizations such as specialized suppliers, industry-knowledgeable universities, trade associations, legal and financial experts, funding sources and government agencies."

The program has supported a bioplastics cluster project to make a biodegradable plastic from Maine potatoes for use in a range of textile, medical, bottling and other products. Among other things, the effort joins two traditional Maine industries, agriculture and textiles, to explore the potential of PLA (polyactic acid) derived from potato starch in the manufacture of fabric. True Textiles, which has a plant in Guilford, has been one of the leaders of the project.

The Maine Technology Institute also supports a cluster of industries in environmental and energy technology, areas of high R&D performance that have been emerging in Maine. The Environmental & Energy Technology Council of Maine (E2Tech) is building private-sector capacity in the targeted industries of energy efficiency, renewable energy, advanced materials, environmental services, and alternative fuels for transportation. These industries constitute what is collectively referred to as the *Cleantech* sector and is an example of how changing economic and environmental conditions and changing demands in markets open opportunities for growth in R&D-performing sectors.[5]

USING STATE FUNDS AS LEVERAGE

A state's role in R&D is best described as catalytic. State agencies themselves are involved with R&D; for example, environmental, agricultural, and natural resource agencies conduct independent research to advance their missions. But most state R&D appropriations are not for R&D performed by state agencies themselves, but rather for independent or semi-independent entities or to institutions of higher education; the actual R&D performance is by the recipients of funds coming through those entities or institutions. And in large part, the state funds are leveraged for much larger investments of public (mostly federal) and private dollars.

Thus, in Maine, about 95 percent of R&D expenditures[6] are funneled through external or semi-independent entities, led by MTI, for distribution to various business and other performers or directly to universities and research institutions. Additional state dollars were provided directly to businesses in the form of venture capital through the Maine Venture Fund and R&D tax credits.

What do the state R&D dollars leverage? Direct matches of grants through MTI or to universities appear to be on the order of between $1.50 and $4.00 for each state dollar. However, it appears that each state dollar funneled through or to these organizations generates $10 to $14 of total public and private financing for research and development (Colgan and Andrews 2009; MTI 2011, 2012; University of Maine 2011, 2012). In other words, state dollars accounted for 7 percent to 10 percent of the total activity they helped generate. Other state dollars invested through tax credits or venture capital may have equal or greater total rippling effect.

It is reasonable to estimate that an annual state investment of 5 percent to 7 percent of the target total R&D expenditures would provide the help needed by R&D performers to leverage both much larger private investment and much larger public dollars from federal agencies. This translates into a state commitment of $50 million to $70 million per year (2010 dollars).

The state's commitment has never reached this level, though significant progress has been made over the last 15 years, with some slowdown in the last few years. The state's general fund appropriation has been fairly steady: from FY 2002–03 through FY 2011–12, it was between $20 million and $25 million per year (Maine DECD 2012). In addition, several general obligation bond issues for R&D research and facilities totaling about $130 million were approved during that period. Assuming five-year payouts of the bonds brings the estimated annual average commitment from FY 2002–2003 through FY 2011–2012 to between $32 million and $37 million per year. The most recent proposed R&D bond issue approved by the legislature in 2012 was vetoed by the governor.

To reach the target of $50 million to $70 million per year would require an additional commitment by the state of about $15 million to $35 million annually. To reach this level may require periodic bonds to finance R&D. The larger challenge, however, is to increase the annual general fund appropriation to the base level—say, $50 million—needed to help move Maine to $1 billion of total R&D spending (by all parties from all sources).

CONCLUSION

A state's per capita income is strongly associated with the educational attainment level of its population and with R&D expenditures by businesses, universities and colleges, and research institutions. R&D expenditures appear to be a surrogate for innovation in products and processes in a state's economy. Since this relationship was highlighted in the late 1990s, considerable progress has been made in Maine: the state has gained in both higher educational attainment and R&D investments relative to the nation. The gap in per capita income has also narrowed.

But 30 and 1000 has become 30 and 1600—or, for a better turn of phrase and converting R&D investment per employed person to total R&D investment, 30 and 1 billion. As far as Maine has come, it has that much farther still to go, especially in the retooling of legacy industries for innovation and the development of new business sectors that are high R&D performers.

ENDNOTES

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2. For personal income: U.S. Bureau of Economic Analysis, Table SA1-3 Personal Income Summary by State, 2010 www.bea.gov/itable (Interactive Data)

For educational attainment: U.S. Census, American Community Survey, Table DP02, Selected Social Characteristics by State, 2008–2012 Average. Available from http://factfinder2.census.gov/.

For R&D expenditures per employed person: National Science Foundation (2010, 2012, 2013, Table 9); U.S. Department of Labor, Table 14, States: Employment Status of the Civilian Noninstitutional Population by Sex, Race, Hispanic or Latino Ethnicity, Marital Status, and Detailed Age, 2010 Annual Averages. Available from http://www.bls.gov/lau/#ex14.

3. The Maine Economic Growth Council (2013), in its report *Measures of Growth in Focus 2013*, set 3 percent of Maine's gross domestic product as the goal for R&D expenditures. The *2010 Science and Technology Action Plan* set a goal of $1.4 billion of total R&D spending by 2015, which it estimated would be 3 percent of gross state product, and a companion goal of $42,000 per capita income (Maine Innovation Economy Advisory Board 2009:11–12)

4. NAICS codes are available at http://www.naics.com/search

5. For illustrations of how innovation can reinvigorate existing sectors or help build new ones in Maine see, James S. (Jake) Ward. 2014. "Research, Innovation, and Commercialization at the University of Maine." Maine Policy Review 23(1): 57–58.

6. Based on 2009 NSF data from State Government R&D Expenditures and Higher Education R&D Expenditures.

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